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Harry Kessler
Metallurgist at Madison Square
(See article, p. 4)

July, 1960

MR STACKS

METALS REVIEW

The News Digest Magazine

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The 15th METALLOGRAPHIC EXHIBIT

Philadelphia, October 17 to 21, 1960

All metallographers—
everywhere—
are cordially invited to
display their best work.

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Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable.

Photographic prints should be mounted on stiff cardboard, extending no more than 3 in. beyond edge of print in any direction; maximum dimensions 14 by 18 in. (35 by 45 cm.) Heavy, solid frames are unacceptable.

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Classification of entry.

Material, etchant, magnification and other desirable data.

A brief statement (if desired) calling attention to any unusual aspect of the entry.

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Exhibits must be delivered before Oct. 1, 1960, either by prepaid express, registered parcel post or first-class letter mail, addressed:

Metallographic Exhibit
American Society for Metals
Metals Park
Novelty, Ohio, U. S. A.

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Class 1. Irons and steels, cast and wrought
Class 2. Stainless steels and heat resisting alloys
Class 3. Aluminum, magnesium, beryllium, titanium and their alloys
Class 4. Copper, nickel, zinc, lead and their alloys
Class 5. Uranium, plutonium, thorium, zirconium and reactor fuel and control elements
Class 6. Metals and alloys not otherwise classified
Class 7. Series showing transitions or changes during processing
Class 8. Welds and other joining methods
Class 9. Surface coatings and surface phenomena
Class 10. Slags, inclusions, refractories, cermets and aggregates
Class 11. Electron micrographs using replicas
Class 12. Electron micrographs (transmission)
Class 13. Color prints in any of the above classes
Class 14. Results by unconventional technique

AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which in the opinion of the judges closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $500 from the Adolph I. Buehler Endowment will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters.

All prize-winning photographs will be retained by the Society for one year and placed in a traveling exhibit to the various Chapters.

42nd NATIONAL METAL CONGRESS & EXPOSITION

Philadelphia Trade & Convention Center——————Oct. 17 to 21, 1960

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METALS REVIEW

The News Digest Magazine

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HARRY KESSLER . . .

The Metallurgist in Madison Square Garden

by James C. Nelson

METALS ENGINEER, SCIENTIST, INDUSTRIALIST, LECTURER—AND BOXING REFEREE! . . . all these things go into the makeup of Harry H. Kessler, one of ASM's most unusual and famous members.

When he isn't conducting the affairs of his far-flung industrial enterprises, or lecturing and entertaining at leading universities and A.S.M. Chapter meetings, he can be seen in his gray flannel uniform, refereeing nationally televised boxing matches in Madison Square Garden.

What sort of circumstances produced this unique combination of metals and Madison Square Garden? It started back in Harry's high school days in the West End of St. Louis. He and his brothers, Ben and Saul, became interested in amateur boxing. Saul even had a professional career which was terminated arbitrarily by his parents after he was knocked out in his sixth bout—he'd won the first five. Harry served as his "second" in that fateful match.

Harry then made his decision to become a metallurgist. He enrolled in the Missouri School of Mines and Metallurgy, helping to pay his way through by acting as a boxing coach. In four years of undergraduate boxing, he was undefeated; and in 1922 was intercollegiate champion in the welterweight division. He graduated in 1924 with a B.S. degree in metallurgical engineering.

His career in the metal industry began with American Steel Foundries in Granite City, Ill. There he worked summers while attending college. He started full-time with A.S.F. after his graduation in 1924, going to the firm's Hammond, Ind., plant as a metallurgist. From 1925 to 1933 he worked for the American Manganese Steel Co., St. Louis, and for Banner Iron Works, also St. Louis, the latter as foundry superintendent.

About that time he began his research with Reginald Drant which resulted in the Sorbo-Mat Process, which makes possible the economical casting of stronger and finer gray iron through alloying. Today the process, the company formed to spread its use and the name Kessler are world-famous in the metals field. He operates 12 plants in this country which serve some 52 foundries licensed to use the Sorbo-Mat Process. Most of the foundries retain him as a consultant, and consequently he must travel about 200 000 miles a year coast-to-coast. The New York Times has called him "one of America's top industrialists" and "No. 1 foundry troubleshooter in the nation".

Even as he was becoming firmly established as a prominent industrialist, he was not entirely happy. Something was missing. He found it again in his first love, boxing. (He had received a licence as boxing referee in St. Louis in 1928). He began to referee more and more fights until today he is probably the top referee in the business, having officiated at something over 3000 bouts.

Thousands of fight fans know him as the efficient, dapper-appearing referee in outstanding matches. Chances are if one turns on his television set to watch a nationally televised bout, the referee will be Harry Kessler.

In telling of his early days of officiating, he recalls his unusual method of keeping score. In the absence of present-day score cards, Harry placed the same number of pennies in his watch pocket as there were rounds in the bout. At the end of each round he would place a penny in either the right or left hand pocket, depending on the winner of the round. At the end of the bout he counted the pennies to determine the winner. He claims he never got mixed up as to which pocket meant which fighter!

He realized a dream of long standing when he was given the assignment of refereeing the Rocky Marciano-Archie Moore heavyweight championship fight. And although he says this was one of his most colorful bouts, he had already worked several championship flights—between Willie Pep and Charlie Riley, and between Joey Maxim and Archie Moore, both in St. Louis. His first title bout in New York was that between Sandy Saddler and Teddy "Redtop" Davis. He considers the match when Carmen Basilio took the world welterweight title from Tony DeMarco his "biggest ring thrill".

Members of several A.S.M. Chapters know Harry not only for his stimulating lectures on foundry practices, but also for his highly entertaining pre-meeting "coffee talks" on his hobby. He has lectured to other major engineering societies and engineering colleges such as Massachusetts Institute of Technology, Penn State University, University of Michigan, California School of Technology and his alma mater, Missouri School of Mines and Metallurgy.

In addition to his membership in the American Society for Metals, he is affiliated with American Foundrymen's Society, Institute of British Foundrymen, A.I.M.E. and the Engineers Club of St. Louis. He also takes part in many

(Continued on p. 5)

Visiting Lecturer

Cyril Stanley Smith, University of Chicago, Presented a Lecture on the "Effects of Explosive Forces on the Structure of Metals" at Carnegie Institute of Technology, on the A.S.M.'s Visiting Lectureship Program. He was introduced by Kent R. Van Horn, left, director of research, Aluminum Co. of America. G. L. McCabe, head of the department of metallurgy at Carnegie Tech, is at the right

Panel Sheds Light on New Heat Treating Ideas

"NEW IDEAS IN HEAT TREATMENT" were covered in a panel meeting held by the Detroit Chapter. C. E. Wenger, vice-president, Industrial Heating Equipment Co., was moderator.

C. C. Hascall, supervisor of metallurgy, manufacturing research, Ford Motor Co., spoke on "Production Austempering and Martempering" as used by Ford to control distortion during hardening. Their equipment consists of continuous controlled atmosphere heating furnaces and salt bath quenching. The talk was illustrated with several slides of the equipment and the parts produced by the process.

Warren Rushman, supervisor of metallurgical processing, Detroit Diesel Engine Division, General Motors Corp., discussed "Quenching". He pointed out that the properties of a heat treated steel part are a function of the steel used, the design and the quench, as shown by Grossman; however, few heat treating departments know the potential of their quenching systems, and, therefore, cannot use Grossman's relationship in predicting results. He showed how a tapered cone made of steel of known hardenability can be used to determine the "H" value of a quench. He also showed a correlation between "H" values and readings taken from a "quenchometer", an instrument developed by G. M. Process Development for evaluating the quenching power of a quench system. He also presented data on the effect of accelerated quench oils on the "H" value.

A. Waryas, plant metallurgist, Chrysler Corp., in discussing "Gas Carburizing", showed that theoretical data on the carburizing potential of atmospheres did not correlate with production results. He illustrated this point with examples of production operations at Chrysler and discussed the changes from theoretical values necessary to adequately control surface carbon content and case depth. These changes were a function of the surface area of the part, the number of parts in the load, the pushing cycle and the specific furnace used. Adequate control was established only after extensive testing. Tests by the thin-strip method for carburizing potential, along with carbon concentration bars, were made and correlated with atmosphere control and the variables listed above. While excellent control can be maintained running constant loads of the same parts by this method, control is lost when there are load variations or mixed loads. *(Reported by J. E. LaBelle for Detroit).*

Harry Kessler . . .

conferences and seminars in the metals field.

He is president of four concerns: Sorbo-Mat Process Engineers, St. Louis; Sorbo-Cast Corp., New Brunswick, N.J.; Meehanite Metal Corp., and Foundry Design Co., St. Louis. He is also a director of Chromalloy Corp., New York City. Add to this his activities as consultant to over 150 foundries throughout the Free World and you come up with an incredibly busy man with a multiplicity of interests.

Only one thing supersedes metallurgy and boxing in Harry's life, and that's his family. His wife, Alma, is a talented playwright. They have a daughter, Sheila, 20, and three sons, Steven, 10, Jon, 8, and Harvey, 6.

One more thing: The fees Harry receives for refereeing prize fights he gives to charity—he does it because he loves boxing.

Metals Review is delighted to salute a man who has attained excellence in everything he has set out to do—the metallurgist in Madison Square Garden—*Harry H. Kessler, A.S.M.*

Reviews Advantages of Cold Extrusion of Metals

R. A. QUADT, VICE-PRESIDENT, research and development, Bridgeport Brass Co., presented a talk on the "Cold Extrusion of Metals" at the Students' Night Meeting in Cincinnati.

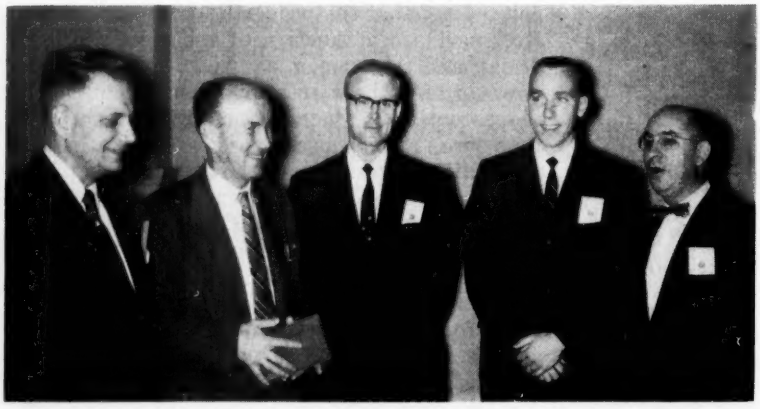
While still in its pioneering stage, cold extruded products are being put to good use and the field is expanding rapidly. This can be substantiated by the number of companies that are now using the cold extrusion process for parts fabrication.

The cold extrusion of aluminum, the metal which has been used to the greatest extent in this process, presents definite advantages over hot forming types of fabrication. In the design of most parts, compensation must be made for certain directional properties that exist in most types of fabrication. However, in the cold extrusion of aluminum, the directional properties are at a minimum. Due to the severe cold working of the metal, a fine equiaxed grain structure is obtained upon annealing, whereas hot extruded aluminum will obtain elongated grains. The cold extruded longitudinal section grain configuration is fine and equiaxed after annealing, much the same as that of the transverse microstructure. In view of the above facts, a high-strength thin-section type structure can be fabricated.

The better mechanical properties that can be obtained by cold extrusion of aluminum presents an advantage where a limiting weight-type problem, such as that experienced in aircraft design, might exist. Thinner housing or cases for missiles are examples of this type problem.

Tolerances being obtained at the present time are also significant. The Sidewinder Missile cases, that are on the order of 6 ft. in length, are being produced with deviations of less than ±0.002 in. on a wall thickness of 0.138 in. AISI 4130 steel is being used to fabricate some cylindrical missile motors and tolerances within ±0.001 on a wall thickness of 0.075 in. are readily being obtained on 4 to 5 ft. lengths. The percent recovery of finished material that can be obtained through the use of cold extrusion practices is also a marked advantage of this process. This can be shown in the cold extrusion of metals such as Zr, Cb, Mo, etc., in which low yield is intolerable. With less scrap being left, these metals are coming under the category of "practical" for industrial usage—in the pure state which must be maintained for the process. Because of the atom configuration of the H.C.P. metals, they must be heated to an elevated temperature to get them to "move" through the die. For these metals, fairly high temperatures are still considered in the cold workable range.

Moving into these elevated temperatures produces the problem of adequate tooling materials and the need for more efficient lubricants. At the present time common grades of high-alloy, air-quenchable toolsteels are used to make cold extrusion dies. It is hoped that in the not too distant future, improved grades of toolsteel can be produced to withstand high temperature usage as die materials for cold extrusion dies. *(Reported by G. D. Lloyd for Cincinnati).*



"Cold Extrusion of Metals" Was Discussed at Cincinnati. Shown are, from left: A. J. Pfetzing, chairman; R. A. Quadt, Bridgeport Brass Co., the speaker; Richard Ernst and William Black, University of Cincinnati; and W. J. Koshuba, vice-chairman

A.S.M. Chapter Briefs

YORK — "Metallography of High-Temperature Materials" was the subject of a talk given before York Chapter by H. J. Beattie, Materials and Processes Laboratory, Large Steam Generator Dept., General Electric Co. As part of his talk, Mr. Beattie showed electron microphotos of the structures of several types of heat resistant alloys. The talk was concluded with a review of new techniques currently being used in electron microscopy.

Nuclear Applications of Cermets and Ceramics

AERONAUTIC ENGINEERS have recently penetrated the sonic barrier and found no additional difficulty with sound, once through the barrier. This is not so in the barrier related to heat. The "thermal thicket" becomes more troublesome the further it is penetrated. As vehicle speed increases, the leading-edge temperature increases, until at 20 times the speed of sound it reaches 10,000° F., according to statements made by Malcolm F. Judkins, special project manager for special nuclear fuels, Sylvania-Corning Nuclear Corp., who discussed "Cermets and Ceramics—Their High-Temperature and Nuclear Applications", at a meeting of Penn State Chapter.

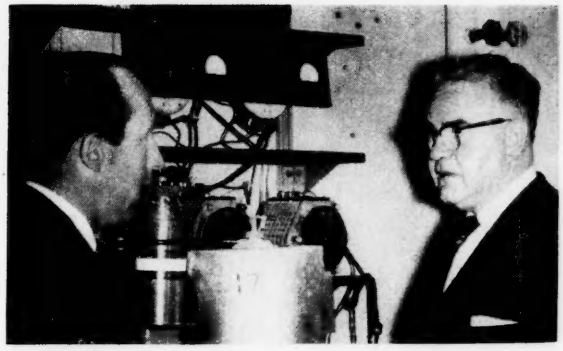
Available chemical fuels will produce temperatures up to 9470° F. Other types of fuels yield temperatures up to 50,000,000°. Fuel is therefore not a problem, but materials for containing reactions pose serious difficulties inasmuch as 6650° F. is the temperature limit on available materials.

The aerodynamic heat generated on the leading edges of missiles can be dissipated or tolerated in several ways: radiation, heat sinks, sweat cooling, ablation or by the refractoriness of the material. Beryllium is a good heat sink because it has a high heat capacity. Bakelite is a good ablative material; as it melts on the surface and vaporizes, it carries away large quantities of heat.

For strength at high temperatures, investigators have turned to refractory metals, cermets and ceramics. Tungsten, the best of the refractory metals, has a tensile strength of 11,000 psi. at 3500° F., and 4260 psi. at 4500° F. This metal is rather difficult to produce and fabricate owing to its high melting point and hardness. The metal is being fabricated by powder metallurgical techniques, consumable arc melting, electron beam melting and direct elaboration. High-purity tungsten (99 999%) shows some very interesting properties previously unrealized. Tungsten and molybdenum, however, have drawbacks in that they oxidize very readily. Protective coatings for these metals are effective only so long as they completely seal the surface of the refractory metal from the atmosphere.

Cermets have good strength at high temperatures, but have very low impact strength.

Uranium dioxide is presently being used for nuclear fuel. Tests are being conducted on uranium carbide as nuclear fuel because it is stronger and more refractory than uranium dioxide and is a better thermal conductor. The isomorphous series between uranium nitride and uranium carbide has a greater uranium-atom density than uranium dioxide and may possibly replace it as a fuel in some reactors. *(Reported by Robert J. Yinger for Penn State).*



Malcolm F. Judkins, Right, Discusses Research Work in Oxide Systems With Arnulf Muan, Chairman, at a Meeting of Penn State Chapter

Materials for Thermo-Electro Power Generation

"MATERIALS IN THERMO-ELECTRIC Power Generation" were reviewed by R. R. Heikes, Westinghouse Research Laboratory, at an Eastern New York meeting.

The voltage produced across a common thermocouple is the voltage being considered as a source of power. This voltage is a result of the joining of two dissimilar metals and maintaining their junctions at different temperatures. A voltage will then be generated equal to the Seebeck coefficient times the temperature difference between the hot and cold junctions. A quantative analysis of a thermo-electric generator demonstrated that the necessary material parameters for efficient operation are high Seebeck coefficient, low electrical resistivity and low thermal conductivity.

The thermal efficiency can be separated into a Carnot efficiency (highest possible efficiency in such a system) and an efficiency index containing the parameters of the materials. The present thermo-electric materials are theoretically capable of a thermal efficiency of about 17%. This corresponds to a material efficiency index of 0.25.

The speaker also stated that Westinghouse is currently building a 5000-watt thermo-electric generator. *(Reported by Louis Ianniello for Eastern New York).*

METALLURGICAL NEWS AND DEVELOPMENTS

SEEK USES FOR DEPLETED URANIUM

Although there appear to be many potential uses for depleted uranium, there are not at present any outstanding applications. Thousands of tons are available for whatever uses appear to be practicable. Potential markets for the material appear to include metallurgical applications in special alloys and high-speed steels, and for high-density metals; possible increased use in the field of ceramics; chemical applications; radiation shielding; cathodic protection and possibly for use in fast breeder reactors of the future. Of these the metallurgical applications seem to hold the most promise.

WELDED STAINLESS FOR HIGH STRENGTH

Experimentally, cylindrical rocket chambers capable of withstanding hoop stress of 305,000 psi. have been made by spot-welding multiple layers of paper-thin strips of AM-355 stainless steel. The foil-gage strip is wound in the desired shape and then spot welded for permanence.

TECHNICAL NOTES

A new zinc alloy containing 0.8% copper and 0.15% titanium offers greater creep resistance, lower grain growth and a lower coefficient of expansion than existing alloys. It is expected to find use in builders' hardware, automotive parts and electrical equipment.

ELECTRON BEAM WELDING

Improved nuclear fuel elements are being made at the Hanford laboratories of General Electric Co. through use of an electron beam vacuum welding process. Engineers in charge of the operation claim that the new process is less expensive, as far as welding materials and power are concerned, than inert gas shielded tungsten welding. Welding quality is also said to be better and more consistent and offers special advantages in joining small thin components.

LARGE SINGLE CRYSTALS

A new arc fusion crystal growing process has been developed to grow large refractory crystals such as tungsten, molybdenum, tantalum, columbium, vanadium, titanium carbide, titanium diboride, columbium carbide, molybdenum disilicide, titanium monoxide and other substances. Although larger crystals can be made, current techniques are producing crystals in cylindrical form in diameters from ¼ to 1 in. and in lengths of a few inches to more than a foot. Availability of the large crystals will assist research in the properties of high-temperature materials.

T-1 STEELS IN CAST FORM

A West Coast foundry has been licensed to produce the patented T-1 constructional alloy steel in cast form. The material in cast form is said to retain the basic mechanical properties of the wrought material with the added advantage of permitting the alloy to be provided in almost any shape and size.

AIR BEARINGS

Research which has been carried on for many years to find a bearing which is nearly frictionless and which will operate under all temperature conditions has nearly perfected the air bearing. In this type of bearing, the shaft floats on air in the bearing and no lubricant is required. One bearing of this type uses powder metal parts through which air can be forced uniformly around the entire inner diameter of the bearing. Air bearings are said to operate at speed ranging from near zero to 400,000 rpm. with practically no friction, no contamination and negligible noise and vibration.

BERYLLIDES ATTRACT ATTENTION

Industry and governmental researchers are investigating a new class of engineering materials known as beryllides. Detailed information on the compounds of beryllium and other metals are now classified as secret, although it is known that the new materials have considerable potential use in nuclear and high-temperature applications.

NEW MAGNETIC ALLOY

A new magnetic alloy, Fernico-5, has been developed by General Electric Research Laboratory. Major significance of the new alloy in its thermal expansion characteristics, closely matching those of alumina, the ceramic it will most frequently be used with. The close matching of thermal expansion properties will prove helpful in making such products as electron tubes, capacitors, high-temperature circuits and other electrical and electronic components, all of which require ceramic-to-metal seals. Key to the improved expansion characteristics is vacuum melting which makes unnecessary the addition of elements formerly used to control oxygen levels.

Manufacturing and Alloying of Aluminum

C. L. Brooks, Center, Reynolds Metals Co., at Southeastern Ohio, Is Shown With H. W. Rathmann, Left, and T. W. Merrill

CARSON L. BROOKS, ASSISTANT director of metallurgical laboratories, Reynolds Metals Co., spoke at Southeastern Ohio Chapter on "Manufacturing and Alloying Aluminum".

Aluminous ores called bauxites are refined by the Bayer process and calcined to obtain pure alumina. The alumina is electrolytically reduced by the Hall process to obtain aluminum metal. The production of 1 lb. of aluminum metal requires approximately 4 lb. of bauxite, ¾ lb. of carbon, and 8 kwh. of electricity.

The reduction pots are essentially steel boxes that have carbon linings which act as cathodes. The pots are filled with molten cryolite and carbon anodes extend down into the cryolite bath. Alumina additions are made to the bath and are reduced to aluminum metal. The aluminum accumulates on the bottom and is tapped periodically.

Although there is an increasing demand for high-purity aluminum, most of the metal is used in an alloyed form. Alloying with copper, silicon, manganese, nickel and chromium can be accomplished in the reduction pots but alloys of elements such as magnesium and sodium must be produced in reverberatory furnaces that are either oil or gas fired.

Mr. Brooks explained that many of the more popular aluminum alloys are of copper and silicon. The copper-aluminum alloys are capable of being solution heat treated and age hardened to promote high strength whereas the silicon-aluminum alloys have excellent casting properties and relatively high strength. *(Reported by S. F. Isler for Southeastern Ohio).*

Offer New Technical Translation Service

A NEW TRANSLATING SERVICE is being provided by an organization known as the "European Association for the Exchange of Technical Literature in the Field of Iron and Steel Metallurgy" (Association Europeenne Pour l'Echange de la Litterature Technique dans le Domaine de la Siderurgie) with headquarters in Luxembourg. The objective of the organization is to facilitate the distribution of translations of periodical literature concerned with iron and steelmaking, particularly from the languages of the Eastern countries.

The translations will be provided by five organizations, as follows, and the translations will be from the Eastern language of origination into the language of the country represented by the organization doing the particular piece of work:

Associazione Italiana di Metallurgia, Milan
Centre de Documentation Siderurgique, Paris
Centre National de Recherches Metallurgiques, Liege
Gessellschaft fur Forderung der Eisenhuttentechnik, Dusseldorf
Groupement des Industries Siderurgiques Luxembourgeoises, Luxembourg

Notification of availability of translations is by means of a card service. Subscriptions to the card service are $4 per year, and it is expected that about 500 to 600 cards will be issued per year, each card giving the title and source of the original article, the language of origination and of translation. the issuing agent and the price of the complete translation.

Requests for further information should be addressed to the above association at 29, ave. de la Porte-Nueve, Luxembourg.

Formation of the Elements —A New Theory

A NEW THEORY ON THE FORMATION of elements of the universe was recently expounded during a symposium in Washington, D. C., which featured the annual meeting of the National Academy of Science. The theory suggests that elements were manufactured in nuclear cauldrons of giant, dying stars.

According to the panelists participating in the symposium, nuclear transmutations in the hot interiors of the stars caused matter to be constantly changed into ever heavier elements. In some instances the processes might have been completed in a few minutes, but in others the process might continue for thousands of years.

In a later step, there might have been a tremendous stellar explosion which shot the elements out into space to form new stars which subsequently went through the same cycles. Elements thus formed range from hydrogen to uranium.

The theory and its explanations were presented to the symposium by William A. Fowler, California Institute of Technology; E. E. Saleter, Cornell University; Jesse L. Greenstein, Mount Wilson and Palomar Observatories, and Fred Hoyle, Cambridge University. The panel of astrophysicists was moderated by Hans A. Bethe, Cornell University.

According to the panelists, the new theory is basically a synthesis and refinement of previous ideas. However, in their synthesis the scientists have provided a possible answer to one of the oldest and greatest cosmological questions about the universe.

The formation of elements having atomic weights up to that of iron has been explained to the satisfaction of most scientists. They are of the opinion that elements in this range could have been created by the successive additions of alpha particles to the nucleus of the carbon 12 atom.

The formation of these elements could have taken place at temperatures of a few hundred million degrees. Temperatures of this magnitude and higher are believed to exist in the center of red giant stars.

The mystery of the heavier elements remained unanswered. The new theory indicates the possibility of two methods. The first can be likened to a slow atomic cooking process in the interior of the stars. The second, rapid method, is the explosion described earlier. Explosions of this nature are the type that convert stars into what are known as supernovas.

The key to both processes is a form of atomic transmutation in which neutrons are captured by the nucleus of an atom. As this capture takes place, the atom is converted into a different, heavier element.

The slow process described by the scientists could be continued for as long as 100,000 years. The assumption was made that when the interior temperature of a giant red star reaches five billion degrees, the elements suddenly disintegrate into alpha particles and neutrons. The neutrons would then be absorbed by heavy elements in cooler parts of the star to form even heavier elements.

Abundance of any elements would be proportional to their nuclear cross sections or their receptivity to neutrons. If the element had little affinity for neutrons it should be relatively abundant because of its resistance to transmutation.

Several elements and isotopes could not have been created by the slow process, according to the new theory, because they are radioactive and would have decayed before they could capture sufficient neutrons to be converted into heavier elements.

The theory of the exploding super stars would explain the creation of the missing elements. In the rapid process, the scientists conjecture, as the temperature reached the five billion degree mark, the centers of the stars began to contract and the inner cores collapsed. They theorize that in a few minutes a core measuring as much as 12 000 miles could collapse into half that size.

When the core collapsed, the outer shell caved in, was heated up and finally exploded in a tremendous thermonuclear explosion. This reaction produced an immense flux of neutrons which then created the missing heavier elements. Included in this group would be short-lived elements heavier than uranium.

The scientists theorized that supernova explosions might occur approximately once every 400 years in every galaxy. New giant red stars are then created by the dust remaining from the previous explosions. The process then repeats itself over and over.

Los Angeles Pioneers Multiple Course Plan

THE PIONEERING LOS ANGELES CHAPTER, in their third year of presenting M.E.I. courses, recently graduated 119 students from four different courses—Elements of Metallurgy, Heat Treatment of Steel, High-Temperature Metals and Stainless Steels. The instructors were: Willis T. Chandler, Rocketdyne; Stanley Pohl, Aeronutronics; Morris Tiktinsky, Lockheed; and David R. Apodaca, Autonetics. The M.E.I. committee chairmanship was in the able hands of Fred K. Landecker, Metal Improvement Co.

The Los Angeles Chapter sponsored the first M.E.I. class in 1957-1958—Elements of Metallurgy. In 1958-1959, two classes were held concurrently—Heat Treatment of Steel and Elements of Metallurgy.

The concept of presenting more than one course per year is spreading to many chapters. For example, Chicago-Western hopes to offer as many as ten different M.E.I. courses this fall if a sufficient number of prospective students express an interest in them.

Chapter-sponsored courses are growing by leaps and bounds. In 1957-58 there was one class. The next year there were five classes. This year 24 chapters are sponsoring M.E.I. courses.

All the chapters that have presented M.E.I. courses have been pleasantly surprised at the response—last-minute response in particular. For example, when the educational committee of the North Texas Chapter announced plans for an M.E.I. course, two students had enrolled one week before the deadline. Ten students had enrolled one day before the deadline. However, 54 students ultimately signed up for the course. Moral to educational chairmen: Don't underestimate the potential response to your next M.E.I. educational program.

Adds Regional Managers

THREE NEW REGIONAL MANAGERS have been added to the staff of the communications department of the American Society for Metals. They are David A. Lewis, Pittsburgh, William A. Graham, Chicago, and David H. Brooks, West Redding, Conn. The new appointments reflect A.S.M.'s efforts to provide greater service for *Metal Progress* magazine, the metal shows and other Society communications media for the metal industry.

Lewis, who joins A.S.M. after eight years with *Mechanization* magazine, will manage the Pittsburgh area, extending from Erie to Rochester. Rodney W. Cramer, formerly in charge of Cleveland-Pittsburgh operations, will concentrate exclusively in Ohio as Cleveland regional manager.

Graham, after seven years' experience with *American Metal Market* and *Building Construction Illustrated,* assumes responsibility for the Chicago region. Donald J. Walter, formerly Chicago regional manager, becomes A.S.M. regional manager in Detroit.

Brooks joins the New York Office after six years in advertising with Bridgeport Brass Co. and Cunningham & Walsh, Inc. He will handle the newly created New England territory, and will be headquartered in New York City. Continuing operations from the New York office are John B. Verrier, Jr., New York regional manager, and Fred Stanley, Philadelphia regional manager.

Fred Robbins, Bliss & Laughlin, Inc., Principal Speaker, Is Shown at Graduation Exercises of Los Angeles' Four M.E.I. Courses. From left are: Mr. Robbins, D. R. Apodaca, W. T. Chandler, F. K. Landecker, S. Pohl, M. Tiktinsky, and H. A. Curwen, chairman of the Chapter

Metallography as an Art and a Science

"ART AND SCIENCE IN THE HISTORY of Metallography" was the subject of the Sauveur Lecture given in Philadelphia by Cyril Stanley Smith, professor of metallurgy at the Institute for the Study of Metals, University of Chicago.

Dr. Smith spoke of the development of metallography, which has its roots in prehistoric times, but became recognizably modern only after the work of Henry Clifton Sorby who was the first, in 1864, to use a microscope to study a sample that had been prepared in a manner that would reveal the structure. Centuries before this date Greek philosophers had speculated on the nature of matter and in the 17th century there had been some remarkably prescient speculations of the properties of matter in terms of the shape and arrangement of the parts composing it. In the 16th century descriptions were first written down of the age-old practice of selecting wrought iron and steel and controlling the composition of bronze on the basis of the texture of their fractures. Etching was used in the 2nd to 10th centuries to reveal a decorative pattern on welded swords but was thereafter forgotten in Europe until the 15th century, when decorative patterns began to be etched on armor. No use was made of etching for scientific purposes until the end of the 18th century. Oriental metallurgists were more sensitive to structure and Damascus and Japanese swords owe their famed superiority to the surface treatment which was given to the finished sword to reveal a texture which was directly related to serviceability. "Damascus" gun barrels were also etched to display a decorative macrostructure which depended on forging practice, and it was a Swedish factory for duplicating the oriental product that inspired Rinman's research on etching which first definitely revealed the presence of a carbonaceous material in cast iron and steel. In 1748, John Hill, in a study of rocks, reported growth steps and speculated on the nucleation, growth and interference of crystals.

Cyril Stanley Smith, Left, University of Chicago, Accepts Sauveur Memorial Lecture Citation From Fred Cooper, Philadelphia Chapter Chairman

Tschernoff in 1868 deduced the existence of the critical point in steel from a change in texture of a machined gun forging and confirmed it by fracture tests on heat treated metal. Brinell greatly refined this approach in 1885 but it was destined to be eclipsed by the studies of Sorby and Osmond, particularly after the results of metallography were combined with thermal analysis in 1887. Although mineralogists applied the phase rule to their structures as early as 1887, metallurgists did not do so until 1900.

American metallurgists played an important role in the early days of metallography. Howe, in 1888, critically examined the observations and conflicting theories of the European metallurgists and resolved them into a unified theory. It was he who gave to microconstituents many of the names that we use today. Albert Sauveur, in whose honor this meeting was held, studied under Howe. He used quantitative metallography for the first time and contributed much to the understanding of the hardening of steel. He also founded a journal specifically for metallographists, which for ten exciting years recorded the advances in metallography. He was a truly great scientist, pioneering both in developing the science and applying it in practice. *(Reported by John P. Clark, Jr., for Philadelphia).*

Establishes Scholarship

THE CLEVELAND CHAPTER A.S.M. has established a new M.E.I. scholarship to be presented annually to a metalworking employee in the Cleveland area who shows outstanding capacity as a student of the Metals Engineering Institute.

Recipient of the first scholarship, presented at the Chapter's May meeting, was George Rolfe, metallographer in the Research and Development Department, Thompson Ramo Wooldridge. He completed, with honors, the course, "Elements of Metallurgy".

He has elected as his scholarship course "Heat Treatment of Steel".

Presenting the scholarship was James Long, Chapter chairman. Ray T. Bayless, former assistant secretary of the A.S.M., congratulated Rolfe on his achievement.

New Methods for the Removal of Metals

Cincinnati Members Heard Norman Zlatin, Metcut Research Associates, Inc., Speak on "Metal Removal". He is shown with A. J. Pfetzing, chairman, and John Kahles, Metcut

WITH HARDER MATERIALS BEING developed it is necessary to utilize new methods for metal removal, according to Norman Zlatin, Metcut Research Associates, Inc., who spoke on "New Developments in Metal Removal" at Cincinnati.

Mr. Zlatin first went into usage of ceramic tools. The ceramic tools have the advantages of high metal removal and being resistant to oxidation at high temperatures; its weakness is brittleness. This is especially apparent on intermittent cutting. New techniques will have to be developed before ceramic tooling realizes its potential.

Chemical milling is a process by which a piece of metal is formed by the dissolving of excess metal. An example of a bulkhead was used to illustrate this process. The steps necessary for chemical milling are: cleaning the base metal; masking the workpiece; stripping the mask on the area to be dissolved; etching the workpiece; and final cleaning and stripping operations. The penetration rate of this method is approximately 0.001 in. per min.

Machining by erosion methods is accomplished by electrospark and electrolytic techniques. The electrospark consists of rapid electrical discharges occurring at a rate of 20,000 to 300,000 cycles a min. The spark vaporizes the base metal and the electrode is formed to the shape that is desired on the base metal. This process is used for drilling and complicated die sinkings.

The electrolytic method uses a combination of abrasive grinding and electrolytic erosion. Examples of products produced by this method are dovetails on turbine buckets and honeycomb structures.

Another metal removal method is ultrasonic machining, in which the abrasive grains do the cutting. The grains are carried in a slurry that passes over the workpiece and underneath an oscillating tool. This method is being used extensively on nonmetallics such as ceramics, glass and silicon, and has been used extensively in the production of transistor crystals.

Mr. Zlatin then explained the work now being done on electron beam methods and ultra-high machining speeds. Although they are not developed to a point where they can compete with present methods, they are opening a new phase in machining. *(Reported by George W. Rebeck).*

Materials for the "Atlas"

A. HURLICH, HEAD, MATERIALS Research Group, Convair-Astronautics, spoke on "Materials and Fabrication of the Atlas Missile" at Vancouver Island. His talk included a description of the basic design of the Atlas missile as a monocoque structure. Essentially, the 10-ft. diameter, 70-ft. long structure is an extremely thin-skinned "balloon" kept rigid by internal pressurization with helium gas. The missile, its hardware and plumbing, contribute an amazingly low percentage of its fully loaded, fly-away weight.

The choice of cold worked type 301 stainless for the skin was based on high strength-to-weight ratio, good corrosion resistance, good low-temperature properties (particularly its notch insensitivity), weldability and ease of fabrication. The skin is stressed to 90% of its yield strength. The 6A1-4V titanium alloy was used for the helium bottles because of excellent cryogenic properties and high strength-to-weight ratio.

The talk was well illustrated with slides which showed various steps in construction of the missile skin and components. An interesting feature was the adaptability of the Atlas missile to such peaceful uses as a research satellite booster vehicle or even as a man-carrying vehicle. Movies of the launching of an Atlas missile and of views of the earth taken from 600 miles up were shown. *(Reported by R. D. Barer).*

D. L. Mordell, McGill University, Spoke on "Engineering Education" at Montreal. Shown are, from left: J. J. Dionne, Ecole Polytechnique student; Prof. Mordell; Howard Fritz, McGill student; H. H. Yates, chairman; Andre Charest, Ecole Polytechnique; Michael Oko, McGill student; and Andre Hone, Montreal student

Engineering Education in an Age of Adventure

DONALD L. MORDELL, dean of the Faculty of Engineering, McGill University, spoke on "Engineering Education in an Age of Adventure", at Montreal.

Pointing out that young men who are about to enter a university in the next four or five years will reach the peak of their careers about the year 2000 A.D., Dean Mordell posed the question "How shall we educate young men so that they may play their part in the world—and the engineering world—of 2000 A.D.?" He pointed out that although many of our present-day developments are based on knowledge which was available in 1900, it would have been virtually impossible for anyone to predict, at that time, the complexity of life as we know it today. It is equally unlikely that we can conceive adequately some of the developments that our graduates of the next few years will have to contend with in the year 2000.

Quoting extensively from the Inaugural Lecture given in 1872 by Professor G. F. Armstrong at the opening of the Department of Practical Science, Dean Mordell emphasized that our current problem was equally recognized at that time. The challenge was met by those pioneers of engineering education in Canada by offering a firm grounding in principles and in their methods of application. The importance of culture and the relationship of the engineer to society were also considered in these early courses of study.

Engineering becomes increasingly important as the technology of a society advances. An understanding of men and morals may have served as adequate foundation for administration and government at one time but, in this age we are about to enter, some knowledge of materials and machines will be equally essential.

In planning engineering education, therefore, we must keep in mind that in addition to being engineers these men will be part of a complex technological society. It will be from their ranks that many of the leaders of industry and government will be drawn and we must do our very best to prepare our graduates for this growing responsibility.

The Chapter entertained technical school principals and university scholarship recipients at this meeting. Chapter scholarships were accepted on behalf of their schools by J. W. Jardine of the Montreal Technical Institute and W. W. Werry of the Montreal Institute of Technology. Chapter scholarships were presented to J. J. Dionne, Ecole Polytechnique, and to M. U. Oko, McGill University (The Gordon Sproule Memorial Scholarship). G. M. Young, recent past president A.S.M., presented National Foundation Scholarships to Andre Charest, Ecole Polytechnique, and H. M. Fritz, McGill University. *(Reported by D. B. Caryll for Montreal).*

How a Metallurgist Looks at Ceramics

JOSEPH E. BURKE, MANAGER, Ceramics Studies Section, General Electric Research Laboratories, explained how "A Metallurgist Looks at Ceramics" at a meeting of Oak Ridge Chapter.

Dr. Burke pointed out several interesting facts which tie metals and ceramics together historically. As early as 4500 B.C., men prepared ceramics which required temperatures in the 1000-1100°C. range. Metallurgy had its start from these high-temperature ceramic studies and cast bronze objects were being made by 3500 B.C. The ceramics of interest were primarily silicates until

recent years when metal oxides have become important. These materials resemble metals in that they are single-phase crystalline solids.

Several uses of ceramics were illustrated. These materials have performed major roles in the electrical, electronic, nuclear, chemical and machine tool industries. The electrical and electronic industries use ceramic insulators of numerous sizes and shapes which have a wide range of physical properties. Ferrites, which consist of homogenous magnetic oxides of manganese, zinc, nickel and other metals, have been developed and are used in memory computers and other electronic systems to control high-frequency electromagnetic conductivity. Oxides of fissionable materials, such as uranium, are used widely in the nuclear industry. Enamel coatings have been used in the chemical industry to protect structural materials from corrosion. Mention was also made by the speaker of the uses of ceramic materials in the machine tool industry for making cutting tools.

The processing of metals and ceramics is quite similar since both types of materials can be formed by casting, extruding, pressing and rolling. To successfully fabricate a part, whether metal or ceramic, it is necessary to understand the processes which occur during fabrication. For example, one problem of extreme importance in ceramic parts made by sintering is porosity. Pores result from original small-grain interactions and remain as voids as the grains grow during thermal treatment. These voids are observed to disappear rapidly if they lie at a grain boundary and very slowly if they do not. Hence, additions to the material to prevent grain growth are quite effective in increasing the density of the final product.

Just as with metals, the environment of ceramics must be carefully controlled during heat treating. For example, if the heat treating environment of $MgFe_2O_4$, one of the ferrites used in electronic equipment, is too oxidizing, Fe_2O_3 is precipitated, which alters the magnetic properties of the material.

In discussing the mechanical properties of ceramics, Dr. Burke divided these materials into three classes, depending on their ductility: Ceramics which will undergo no plastic deformation, exemplified by quartz; ceramics ductile only at elevated temperatures, such as glass, which deforms by viscous flow; and crystalline oxides, which deform by a slip process (for slip to occur in crystalline oxides such a Al_2O_3, considerable ionic movement must occur, and hence high temperatures are necessary); and ceramics which will deform plastically at ambient temperatures, such as sodium chloride and magnesium oxide, which deform by a slip process which requires less energy for activation than the deformation process which occurs in some of the materials of the second group.

Dr. Burke concluded by pointing out that the properties of ceramics and metals overlap in many cases and offer materials with a wide range of properties. The requirements of a particular application should be carefully analyzed and the material, ceramic or metal, chosen which most closely fits these specifications. *(Reported by H. E. McCoy).*

A.S.M. Chapter Briefs

OTTAWA VALLEY—Quench cracking in some alloy steels can be elminated by replacing certain of the normally used alloying elements with silicon, according to Gordon E. Willey, vice-president in charge of sales, Electro Metallurgical Co., Division of Union Carbide Canada, Ltd. Dr. Willey spoke before Ottawa on "The Application of Nonferrous Metals in the Iron and Steel Industry".

Explosive Forming

R. A. Cooley, Propellex Chemical Corp., Who Spoke on "Explosive Metal Forming" at Tulsa, Covered the Field From the Selection and Design of Charges Through the Development and Application of Transmission Media to Actual Forming of Parts. Shown are John E. Garol, vice-chairman; Dr. Cooley; and A. E. Marks, chairman

Information on the Art of Metal Cutting

"WHAT IS KNOWN TODAY About Metal Cutting" was covered, in part, by Francis W. Boulger, Battelle Memorial Institute, in the second annual Oscar E. Harder Memorial Lecture of the Columbus Chapter. Mrs. Harder was a guest of honor at the meeting.

Mr. Boulger discussed how machining conditions, properties of the tool and properties of the workpiece influence the success of metalcutting operations. Of these, the latter two factors are of principal interest to metallurgists. Good tool materials must possess high strength and wear resistance and adequate toughness at elevated temperatures. The desirable metallurgical properties of workpiece materials are more complicated. His talk dealt mainly with the effects of workpiece characteristics on machining operations.

Mars G. Fontana, Head, Metallurgical Engineering, Ohio State University, Presents the Annual Student Scholarship Award to Terry Lee Davis, a Sophomore, at a Meeting of Columbus Chapter

Mechanical theories of metalcutting indicate that low deformational and frictional forces are desirable and that these forces vary with the workpiece. Since these forces depend on several complex characteristics of metals the mechanical theories have been of little help to metallurgists trying to improve the machining properties of metals. More progress has come from studies based on cruder, empirical testing methods simulating machining operations of the greatest practical interest.

A variety of practical methods are generally used to compare workpieces under standardized machining conditions. Many of these procedures rate materials in the same order even though they employ widely different testing techniques. Tests of this kind have been used in investigations resulting in improved machining characteristics of metals. They also make possible useful generalizations about the effects of composition and microstructure on machinability.

The effects of changes in composition on the machinability of free-cutting steels and of annealed cold drawn steels seem to be known with fair precision. Subtle differences in composition or microstructure account for the differences in machining properties among different lots of materials fitting the same specification. The coefficient of variation of machinability ratings of samples of the same grade is about 10%.

For a particular composition, the size and distribution of microstructural constituents are important. Conversely, lead and sulphur, which occur as nonmetallic inclusions in steel, are more beneficial when the inclusions are larger.

Machining theory is good enough to predict cutting forces and to select optimum cutting conditions for common metals. Suitable techniques are available for determining, quantitatively, the effect of metallurgical variables on machinability. *(Reported by R. A. Endsley for Columbus).*

Francis W. Boulger, Right, Who Gave the Oscar E. Harder Lecture Before the Columbus Chapter, Is Shown With John G. Kura, Chairman

Cermet Formation and the Control of Microstructure

"NEW CERMET MATERIALS" were discussed by M. Humenik, Jr., Fort Motor Co., at a joint meeting of Dayton Chapter and A.S.M.E.

The cermet systems discussed were those sintered in the presence of a liquid phase. While polyphase materials fabricated by powder metallurgy techniques include many combinations, such as metal-metal, ceramic-ceramic, metal-ceramic, organic-ceramic and organic-metal, only the metal-ceramic system was considered in detail. In particular, the processes important to the control of microstructure in these materials were discussed.

The concept of obtaining many of the desirable properties of both the ceramic and metal in a cermet is a valid one, as evidenced by the very successful metal-bonded tungsten carbide compositions exhibiting unique properties of high hardness, good strength and toughness. They are produced by blending the individual powder constituents, cold forming to a precise shape and sintering the compact at an elevated temperature. During the sintering operation, the liquid phase that is formed promotes rapid densification of the compact.

The most challenging aspect of cermet formation lies in the control of microstructure since the properties of these materials will be determined principally by the microstructure. For example, if the structure comprises isolated pockets of the metal phase, then the properties will be largely those of the continuous ceramic phase. On the other hand, if the metal is present as a thin continuous film surrounding the ceramic grains, then the system may exhibit unique properties, differing from those of the individual phases alone.

To control the microstructure in cermets, it is first necessary to form a coherent compact during the sintering operation. This is no particular problem in carbide-base cermets; however, in many of the metal-ceramic systems, the liquid formed during sintering shows little affinity for the solid and begins to exude, or sweat, from the compact. In such systems, the principal problem to overcome is the poor wetting action of liquid, which in turn is dictated by the various surface energies of the system. In this respect, Dr. Humenik discussed the sessile drop technique being employed to measure wettability and surface energies in liquid-solid systems. Wettability can be controlled by modification of the surface energies involved. The development of metal-bonded graphite at the Ford Scientific Laboratory resulted from basic wettability studies on liquid-metal-graphite systems. By means of certain alloying additions, liquid metals may be made to wet graphite, thus permitting liquid phase sintering techniques to be used in producing a wide variety of metal bonded graphites for use in bearing, electrical, and possibly, high temperature applications. With regard to microstructural aspects in cermets, the distribution of the phases, grain shape and grain size of the ceramic phase are expected to influence the mechanical properties of the composite. In connection with grain shape, angular grains may lead to areas of high stress concentration at the sharp juncture of the ceramic-metal interface. An example of modifying grain shape was illustrated in the nickel-titanium carbide cermet, wherein the carbide grain shape was changed from cubic to spheroidal by adding oxygen.

For optimum mechanical properties, a uniform dispersion of fine-grain ceramic in a continuous metal phase is desired. It is therefore necessary to control grain growth of the solid phase during the sintering operation. The principal factor controlling grain growth is the degree of dispersion of the solid in the liquid during sintering. The dispersion of the solid in the liquid is in turn dependent on grain boundary and liquid-solid interfacial energy relationships. In systems characterized by incomplete grain boundry penetration by the liquid, the solid grains are coalesced and rapid growth of the coalesced grains is obtained.

The development of Ni-Mo-TiC cermets at Ford resulted from microstructure studies. Addition of molybdenum to Ni-TiC lowers the liquid-solid interfacial energy and promotes complete dispersion of the carbide in the liquid metal during sintering, thereby refining the carbide grain size. This results in a cermet having high hardness, increased strength and greater toughness. Ford is extensively evaluating the new cermet (10% Ni, 10% Mo, 80% Ti carbide) as a cutting tool. Tool performance on 1045 steel in standard machinability tests showed up to an order of magnitude improvement in tool life over tungsten carbide base tools. Results obtained from various production machining operations showed a much improved tool life over both tungsten carbide and ceramic tools. *(Reported by W. A. Luce).*

New Metals Problems

D. J. McPherson, Center, Who Spoke on "Problems of Newer Metals" at Rochester, Is Shown With Russell H. Brush, Vice-Chairman, Left, and Frank Gehrlein, Chairman

Role of Semiconductors in a Metallurgist's Work

SEMICONDUCTORS ARE BECOMING of prime interest not only to semiconductor specialists but also to general metallurgists, according to W. Crawford Dunlap, director of semiconductor research, Research Division, Raytheon Co., who spoke on the "Metallurgy of Semiconductors" at Boston Chapter.

This interest stems mainly from the fact that semiconductors, by virtue of the great sensitivity of their electrical properties to impurities and imperfections, are now providing one of the chief proving grounds for theoretical studies of metallurgical interest. Secondly, as the semiconductor industry in itself becomes more and more important, the process metallurgy of the important semiconductors becomes an increasingly active area for metallurgical work.

A discussion illustrated by lantern slides was given of the Czochralski method, zone refining, zone level and floating zone techniques of crystal preparation, together with a discussion of the basic properties of impurity segregation, diffusion and solubility. Advantages of the electrical sensitivity to the impurities for the preparation of more complete phase diagrams than are usually available was mentioned. Recent results on segregation coefficients for impurities in silicon and germanium were discussed.

Metallurgical problems associated with the fabrication of semiconductors into usable transistor and rectifier devices were then outlined. The problems of alloying, including the need for high solubility of the alloying agent, good mechanical strength, good wetting, controlled penetration and compatibility with other process operations were mentioned, and a description of some of the important alloying agents and their carriers for alloying into germanium and silicon was given. Such studies are providing impetus for a great deal of metallurgical work on ternary and quaternary systems, although as yet the total information available on any of the important systems is almost completely lacking. A discussion of the diffusion techniques and problems associated with solubility, junction formation and penetration control and evaluation followed.

A number of recent results on the mechanical properties of silicon and germanium as obtained from a research program at the Raytheon Research Division were discussed. This program involves two parts: (a) Preparing and evaluating dislocation-free silicon and germanium so that the effects of controlled densities of dislocations can be determined; (b) Evaluation of the mechanical properties of these semiconductors with respect to variations in surface condition, crystal orientation, dislocation density and impurity concentration.

The preparation of nearly perfect dislocation-free silicon and germanium has made it possible to move to a new plateau in the investigation of crystal imperfections. The results obtained to date make it appear that condensed vacancy loops are the agencies responsible for the observed properties of these materials in plastic deformation. Addition of n and p-type impurities, such as gallium and arsenic, at high levels produces significant changes in the plastic properties. These results are interpreted through the mass action effect on the concentration of acceptor-type defects and the resulting change in the size and configuration of the condensed vacancy loops. The role of dislocation velocity is also becoming of increasing interest. Direct measurements of dislocation velocity are now being made by the Stein-Lowe method of deforming bars along which a central scratch has been made. The velocity is determined directly by the motion of the dislocations emitted from the scratch as determined from etch pits. *(Reported by D. A. Black).*

Theory, Applications and Control of Furnace Atmospheres

THE THEORY, APPLICATIONS and controls of "Furnace Atmospheres" were discussed by Charles A. Mueller, Lindberg Engineering Co., at a meeting of Detroit Chapter. The basic chemistry of furnace atmosphere was outlined to show the reactions that occur between the atmosphere and the steel during heat treatment. The reactions that occur between the furnace gases themselves were also described.

Originally, furnace atmosphere was used to minimize scaling and decarburization during heat treatment. In addition, many other beneficial uses have been found, such as gas carburizing, carbonitriding, nitriding, sintering and reducing of powdered metals, bright hardening and annealing and carbon restoration.

The carbon equilibrium that exists between the furnace atmosphere and steel during heat treatment was illustrated by slides showing this relationship in the case of straight carbon steel, production steels and toolsteels of all types. Generally speaking, the equilibrium data showed that progressively lower dewpoint temperatures of endothermic atmosphere are required when either the carbon content of the steel is increased or when the temperature of heat treatment is increased. Alloying greatly influences the atmosphere requirements for equilibrium.

The operating characteristics and economics of different type atmosphere generators were discussed. These included the older type charcoal generator, exothermic, endothermic, dissociated ammonia and nitrogen generators. The comparative costs of producing each of these atmospheres, their particular fields of application and their composition were given. The endothermic atmosphere generator is the basic type in common usage today; it is used for neutral heat treating and as the carrier atmosphere in gas carburizing and carbonitriding. Generator control instrumentation has been perfected to such a degree that it is now possible to pre-select and automatically maintain precise carbon potential conditions in the furnace. In most cases, a high hydrogen atmosphere produced from dissociated ammonia can replace the more costly cylinder hydrogen used in heat treating. A special example of the use of dissociated atmosphere was given as the sodium hydride descale bath which utilizes the hydrogen constituent of the atmosphere to react with molten sodium to form sodium-hydride. Other applications include the bright hardening and bright annealing of stainless steel.

Examples of surface treatment to secure particular effects were described, including carbon restoration and nitriding. The importance of prior treatment and surface condition in some applications of controlled furnace atmosphere was stressed.

The fundamentals of atmosphere furnace construction were outlined; gas-tight welded steel shells, door curtains, inlets and vent lines for atmosphere, atmosphere circulation in the furnace and methods to minimize room air infiltration were described. In the selection of furnaces for controlled atmosphere work, there are certain important features which should be considered, such as the capacity of the generator, furnace shell construction, choice of refractory lining materials and auxiliary handling equipment. Many types of controlled atmosphere furnaces were illustrated and their advantages and uses discussed. Among these was the large gantry-type furnace and associated equipment used in the heat treatment of missile bodies and components. These giants of the furnace industry are many stories high, but can be controlled mechanically, thermally and with respect to atmosphere, as closely as the more familiar types. *(Reported by J. E. LaBelle.)*

Awarded Scholarships

At a Recent Meeting of Santa Clara Valley Were, From Left: Jess Wilson, Stanford Research Institute; Gary J. Warren, With the Combined Santa Clara Valley—Golden Gate Scholarship Winner; and J. H. Anderson, San Jose State College Faculty

Complexity of the Heat Resistant Alloys

THE COMPLEXITY OF COMMERCIAL heat resistant alloys led J. R. Mihalisin and R. F. Decker, research laboratory, International Nickel Co., Inc., to simplify the binary and ternary systems in order to understand complex alloy reactions, according to a talk by Dr. Decker at Eastern New York on "Precipitation Hardening".

The initial portion of the discussion was on research on precipitation hardening in nickel-rich titanium, nickel-aluminum and nickel-titanium-aluminum alloys. The conclusions were:

1. That a fcc. precipitate based on δ^1 was

W. G. Fabofsky, Secretary, W. J. Childs, Chairman, R. F. Decker, Speaker, and S. Yukawa, Technical Chairman, Are Shown at a Meeting of the Eastern New York Chapter

responsible for precipitation hardening in all the alloys.

2. That titanium atoms could replace all aluminum atoms in the δ^1 [Ni_3 (Al, Ti)] structure under nonequilibrium conditions.

3. That optimum hardening was a Ti/Al ratio of 1.8 due to optimum coherency hardening. This resulted from maximum disregistry of the coherent δ and δ^1 lattices.

Dr. Decker then introduced more recent work on disregistry and precipitation hardening response from the δ^1 phase. A portion of the aluminum in Ni-Al binary alloys was replaced by several elements X, thus giving Ni-Al-X ternary alloys. These were selected as elements which might alloy preferentially into the δ^1 phase, thus increasing the δ-δ^1 disregistry. The original hypothesis was apparently correct in that a linear correlation was found between the disregistry of the coherent δ and δ^1 lattices and precipitation hardening. Furthermore, it was illustrated that the increment of hardening from replacing Al by element X was proportional to the atomic diameter oversize of element X over Al.

Finally, Dr. Decker illustrated how Ti + Al hardening has been superimposed on the Fe-Ni martensitic reaction by C. G. Bieber of International Nickel Co.'s research laboratory. This has yielded a series of alloys exemplified by the 25% Ni steel which can be heat treated from a soft workable alloy to a high strength level. *(Reported by Louis Ianniello).*

Crystal Growth and Stress Corrosion

EARL A. GULBRANSEN, ADVISORY engineer, Research Laboratories, Westinghouse Electric Corp., discussed "Crystal Growth and Stress Corrosion" at a meeting in Richmond. He indicated that several theories have been developed for explaining stress corrosion behavior, but that only in recent years has direct evidence been presented which shows what is happening in the early stages on a nearly atomic scale.

A corrosion study which has baffled scientists up to the present day was that of an iron column in Delhi, India. This six-ton column has resisted corrosion for almost 17 centuries. Guesses current at various times were that cinders or oxides had been worked into the metal; some special element had been added; the column had been anointed with ghee (butter from a sacred cow); and the dry climate. Samples of the iron taken to England soon rusted. It is now generally thought that moisture is necessary for rapid corrosion and that the dry atmosphere in Delhi had preserved the column.

Current thinking on the corrosion of iron in moist atmosphere indicates that it involves localized chemical attack. It is probably electrochemical in nature, and thus selective in reactivity with different metals. It is also quite selective with respect to attack on grain and subgrain boundaries, precipitated phases, dislocation arrays and localized stresses. Orientation of the attacked phase is also important.

Dr. Gulbransen presented some electron microscope observations which he has made during corrosion studies involving gas phase reactions. With this technique the sites as well as the products of corrosion are preserved. The corrosion products are not dissolved, as is often the case when using liquid media.

Initiation of localized corrosion in oxidation is indicated by the formation of whiskers, whose characteristic appearance depends upon the metal and reaction conditions. For example, whiskers formed on Armco iron in dry oxygen are approximately 100-200A° in diameter and may grow to lengths up to 500,000A°. When this same material is corroded in argon with 10% water vapor, thin blade-shaped platelets form. Furthermore, whiskers can change to platelets when water vapor is added, but platelets cannot become

whiskers. Cold work prior to exposure in dry oxygen produces large rounded platelets on Armco iron. Nitrogen, as an impurity in iron, increased platelet activity in an atmosphere containing water vapor but did not affect the behavior in dry oxygen.

Angular oxide crystals were formed on stainless steels in dry oxygen. Large rounded platelets formed when this material was strained prior to corroding in a wet oxygen environment.

These whiskers and platelets are approximately 30 interatomic planes in thickness, which is about the distance over which dislocation disturbances are found. Dr. Gulbransen postulated that nucleation sites must be aligned by stress or impurities and that platelet formation develops as a result of this alignment. Random orientation is conductive to whisker formation. In some manner, the presence of water vapor causes whiskers to form platelets and platelets to become strongly oriented. Dr. Gulbransen has associated the sites for stress corrosion with the formation of these large oxide platelets. *(Reported by W. W. Berkey).*

Bright Hardening and Brazing of Stainless Steels

"BRIGHT HARDENING AND BRAZING of Stainless Steel" was discussed at Hartford by Frederick C. Schaefer, sales manager, American Gas Furnace Co.

Mr. Schaefer described batch and shaker-type equipment available for bright hardening, calling attention to the fact that the same type of furnace used to anneal austenitic stainless is also used to harden the martensitic type. Cracked ammonia and dry hydrogen are commonly used for atmospheres. Occasionally, rare gases, such as argon and helium, are used for atmospheres, but their cost is usually very high and they are not very effective in maintaining brightness.

The importance of careful atmosphere control was emphasized. Low dewpoint and freedom from oxygen are important for successful bright hardening. Various methods and devices for monitoring dewpoint and atmosphere quality were covered.

It was pointed out that the furnace container must be completely sealed and free of leaks. Leakage points which permit the atmosphere to escape simultaneously allow contaminants to leak into the chamber. Contamination in the oil bath used for quenching may produce discolored work. This problem is reduced by taking the necessary steps to minimize contamination, and, in some cases, by bubbling nitrogen through the bath to remove dissolved impurities. *(Reported by F. M. Lister.)*

Thermodynamic Applications

C. L. MC CABE, HEAD, Department of Metallurgical Engineering, Carnegie Institute of Technology, presented the annual Pittsburgh Night Lecture of the Pittsburgh Chapter on "The Application of Thermodynamics to Industrial Processes".

Prof. McCabe first discussed the current status of utilizing thermodynamic data in the prediction of the concentrations of components in the phases present in industrial furnaces. He noted that in gas-metal systems it is possible in many cases to calculate quantitatively gas solubility in complex metallic solutions providing industrially

C. L. McCabe, Carnegie Institute of Technology, Is Shown as He Received the Pittsburgh Night Lecture Certificate From Gilbert Solar, Chairman

useful information. However, in slag metal equilibrium calculations, the lack of data and the mathematical complexity of handling the activity co-efficient makes the problem of predicting industrially useful information on a broad scale virtually impossible of solution. The work of Lillie of U. S. Steel on sulphur partition in the openhearth was cited as the best example of what we can do in this area at the present time.

The application of the heat balance, materials balance and a consideration of the engineering kinetics was pointed out as a most fruitful avenue for industrial research. The great value of the heat balance was demonstrated by reference to the work of Philbrook on the pneumatic processes, Larson on the openhearth and the Jones and Laughlin group on the blast furnace.

Prof. McCabe then discussed the great help which thermodynamics can give in understanding kinetic processes in industrial furnaces. The foaming of slags and the distillation of zinc were given as examples of this application of thermodynamics. *(Reported by A. E. LaMarche for Pittsburgh).*

How Titanium Is Used in the Aircraft Industry

T. W. Lippert, Titanium Manufacturing Co. of America, Spoke on "Titanium's Use in Aircraft" at an Upper Ohio Valley Meeting. Shown are, from left: Earl Neeb, plant manager, Titanium Manufacturing Co.; Mr. Lippert; and Frank Norris, Wheeling Steel Corp.

TITANIUM'S EXTENSIVE USE IN aircraft is a fantastic achievement, compressing into five or six years the accomplishments that require a generation of normal metallurgical development.

Ingots went from 1 lb. to 5 tons; vacuum melting and annealing were proved feasible production operations; inert-gas chamber welding became routine. These contributions of titanium, stated T. W. Lippert, director of marketing for Titanium Metals Corp. of America, addressing the Upper Ohio Valley Chapter, have had a profound effect on metallurgy and metalworking in general.

It should be so. Titanium is a metallurgist's metal. It was developed by metallurgists for metallurgists. Since its price has always been comparatively high, demands placed on titanium have been exacting. These demands were met by an industry which, in three years, was producing some of the most precise metal products ever known.

The price history perhaps best shows how solid the metallurgical contributions really were, Mr. Lippert added. In five years, prices of titanium mill products declined more than 50%.

Metallurgists developed the metal, now it is up to the businessmen to develop markets.

Pointing out that "any one of a half-dozen companies could supply the present market demands", Mr. Lippert added that manned and unmanned airborne systems and the chemical process industry would account for the bulk of the titanium market in the immediate future. Other markets will open as titanium's prices enable it to advance into less sophisticated areas.

Mr. Lippert, former editor of *Iron Age* magazine and the first employee of TMCA, helped organize the company in 1950. At that time, he said, industrialists were skeptical of the new industry's chances for survival. Despite its many problems, Mr. Lippert said, we consider titanium's foundations firm. The metallurgists, not the industrialist, laid those foundations.

In a question session following his talk, Mr. Lippert said that Russia is probably the most active foreign country developing titanium, with England, Japan, France and Germany working in the field. *(Reported by R. L. LaVaughn for Upper Ohio Valley Chapter).*

Beryllium and Other Light Metals in Atomic Energy

"BERYLLIUM AND OTHER LIGHT Metals in Atomic Energy" was the title of a talk before the Ontario Chapter by E. C. W. Perryman, assistant director, Chemistry and Metallurgy Division, Atomic Energy of Canada Ltd. Light metals are considered for use in the construction of natural uranium power reactor cores primarily because of their very low neutron absorption cross sections (low neutron absorption probability). It is this factor which determines the feasibility of natural uranium fueled reactors in the first place, and which controls the extent of fuel burn-up and the economy of the operation.

For the light metals, aluminum, magnesium and beryllium, the absorption cross sections have the values $0.21 \times 10^{-24}cm^2$, $0.05 \times 10^{-24}cm^2$ and $0.009 \times 10^{-24}cm^2$, respectively, and these are to be compared with the values for the heavy metals —zirconium with $0.18 \times 10^{-24}cm^2$ and stainless steel with $3.1 \times 10^{-24}cm^2$. While stainless steel is compatible with most coolants now considered for pressure tube reactors, its high cross section limits its use to enriched fuel systems and so is of little use to the Canadian program. Zirconium, on the other hand, has a lower cross section than aluminum and because of this it is economical to use it in the 200-megawatt CANDU reactor

in spite of the fact that it costs 100 times more than aluminum.

Aluminum has been widely used for fuel sheathing and constructional purposes in research and production-type reactors but its use in water-cooled power reactors is severely restricted due to its high susceptibility to intergranular corrosion in the typical operating range of 260-300°C. Improved corrosion resistance in an alloy containing 2% nickel and 0.5% iron has been obtained, but the alloy is still inferior to zirconium alloys in respect to corrosion resistance and strength. Considerable promise for aluminum, particularly in the aluminum Al_2O_3 and aluminum-iron dispersion-type alloys, is found in the design of organic cooled reactors, although some difficulty is presented by the relative lack of ductility in the aluminum Al_2O_3 alloys. Aluminum-rich plutonium alloys show promise for future designs as sufficient plutonium by-product of the power program starts to become available.

Because of magnesium's poor corrosion resistance in high-temperature water, its use for fuel sheathing is restricted to CO_2-cooled, natural uranium metal fueled reactors of the type being built in the United Kingdom and France. It has a very low absorption cross section and is compatible with uranium metal and CO_2 up to 450°C. The alloy, Magnox, with small additions of aluminum and beryllium, has good oxidation resistance but is somewhat subject to grain boundary cavitation under the strain caused by uranium swelling. Magnesium-zirconium and magnesium-zinc-zirconium are somewhat better in this respect.

Beryllium has the lowest absorption cross section of all metals and is therefore very attractive for use in natural uranium reactors. While having good high-temperature strength and a high modulus of elasticity, beryllium (as fabricated) lacks three-dimensional stability, is highly toxic and, in use, is subject to helium poisoning, which tends to produce a decrease in ductility over that normally caused by neutron irradiation. While there are great technological problems in the production, fabrication and handling of this metal, they do not seem to be insurmountable. It therefore appears likely that, in the long run, beryllium will play an important part in upgrading the competitive position of nuclear power. *(Reported by J. S. Kirkaldy.)*

M.E.I. Compresses Nine Month Course In One Week Stint

The Metals Engineering Institute, Home-Study Division A.S.M., Completed a Successful Experiment in Group Instruction the Week of June 6. The 15-lesson course "Heat Treament of Steel" which usually requires nine months home study, was conducted in one week at A.S.M. Headquarters. Pictured at right is A. deS. Brasunas, M.E.I. director, and Lewis W. Berger, training supervisor, is standing, center. Students, from left, are: Paul Masterson, Lakeside Steel Improvement Co., Cleveland; Jack H. Wilson, Commercial Shearing and Stamping Co., Youngstown; Eduardo Marcos and George Conzolez, Ciudad Sahagem, Hudalgo, Mexico; R. T. Smith and J. E. Robertson, Grand Rapids Commercial Heat Treating Co., Mich; and C. R. Derhammer, Lakeside Steel Improvement Co.

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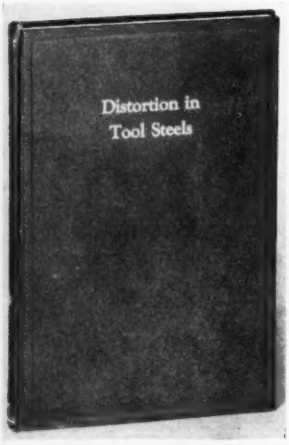

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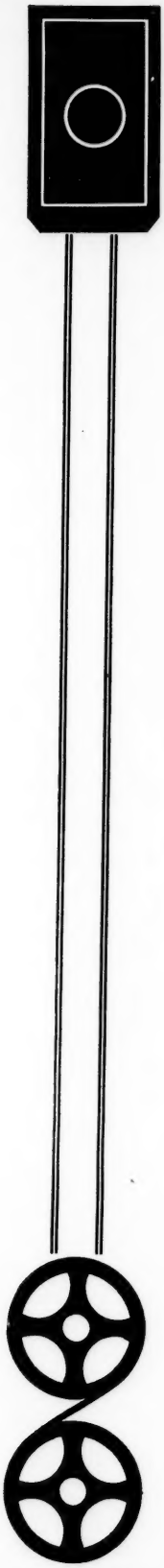

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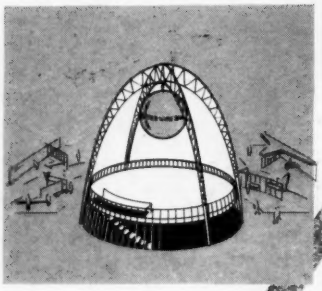

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